Energy Efficiency Systems, Inc.

COMBUSTION EFFICIENCY COMPUTER

MODEL 942-XP

INSTRUCTION MANUAL

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THE POWER TO KNOW ENERAC™

November 13, 1990

Dear Kevin,

I managed to find 2 copies of manuals for the 942X P's. I am sending each one under separate cover. If you have any questions, please call.

Sincerely,

Tom Casucci

division of ENERGY EFFICIENCY SYSTEMS, INC. • 1300 SHAMES DR. • WESTBURY • NY • 11590 • 516-997-2100 FAX (516) 997-2129

CAUTION

When turning the printer on, if you see a heavy black line being printed instead of the usual printout, turn the printer toggle switch off IMMEDIATELY for a second and then turn it back on.

Do not allow the printer to continue printing a heavy black line because this will damage the printer thermal heads. A damaged thermal head will cause the printer either to print nothing orto print letters with some dots missing. The thermal head can be replaced in the field without returning the instrument to the factory.

SUMMARY
OF
OPERATING INSTRUCTIONS

1. BEFORE INSTRUMENT START-UP

A. If you plan to use the instrument on batteries, be sure they have a full charge.

B. Connect the stack probe and the thermocouple to the instrument. Do not insert probe to stack yet.

C. Push down the appropriate button to select the type of fuel used by the boiler and also set the Boiler I.D. # switch to any desired setting that will identify the boiler in the printout.

D. Make sure the printer ON-OFF switch is in the "OFF" position.

2. INSTRUMENT START-UP

A. Turn the instrument on by pushing the "OPER" button down. Both displays will turn on instantly, but you must wait at least two minutes to allow the instrument to warm up.

B. If the instrument is being operated for the first time this day, allow a minimum of 5 minutes for warm-up. Allow at least 10 minutes for warm-up if instrument is cold, or if it has not been operated for one week or more.

3. CALIBRATION PROCEDURE

A. After the instrument has warmed up and is drawing clean surrounding air, make adjustments, if needed, by inserting

the small screwdriver provided, through the corresponding hole on the face plate, and turning the trimming potentiometers as follows:

Push the "TEMP" button down and adjust for a reading of 000 on the upper display.
Push the "COMB" button down and adjust for a reading of 0.00 on the upper display.
Push the "OXYGEN" button down and adjust for a reading of 20.9 on the upper display.

*Use the CO zero adjustment to set the bottom display for a reading of 000.

B. Insert probe into stack, wait two minutes and take your readings as soon as the temperature readout has stabilized.

IMPORTANT: If any of the displays read overrange(i.e.display is blanked except for a one) immediately remove the probe from the stack.

4. INSTRUMENT SHUT-OFF

A. When you are finished with your measurement, take the probe out of the stack, disconnect it from the instrument and shake it vigorously to remove water vapor condensate. Purge the instrument by allowing it to draw ambient air for three minutes. Make sure the probe tip has cooled down before you stow it away.

B. Set the printer ON-OFF switch to the "OFF" position and push down the instrument "OFF" button.

*NOTE: Make sure the air is completely free of tobacco smoke or any kind of residual exhaust fumes when zeroing the carbon monoxide reading.

COMBUSTION EFFICIENCY COMPUTER
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WHAT IS INCLUDED WITH THE INSTRUMENT

Unpack the instrument carefully and inspect it for any signs of damage.

Your Combustion Efficiency Computer includes the following:

- One Energy Efficiency Computer - Model 942-XP
- One stack probe with hose.
- One detachable AC cord.
- One package of smoke paper.
- One smoke paper chart.
- One instruction manual and warranty card.
- One small screwdriver.

HOW THE INSTRUMENT OPERATES

Your instrument can be operated either on 120 VAC/60 HZ (220 VAC/50HZ for export models) or on rechargeable batteries at your convenience. Before operating the unit on batteries, make sure they are fully charged. To charge the batteries, plug the AC cord to any convenient 120 VAC outlet. Plug the other end of the cord to the socket tht is located at the rear of the instrument. Depress the OFF button and let the batteries charge for approximately 16 hours. If you plan to operate the instrument on AC, the batteries do not necessarily need to be charged. When fully charged, the batteries will operate the instrument for approximately four hours continuously, before requiring a fresh charge. CAUTION: NEVER ALLOW THE BATTERIES TO BE DISCHARGED COMPLETELY BECAUSE THIS MAY DAMAGE THEM. To avoid accidental discharging of the batteries, make sure the button marked "OFF" is depressed when the instrument is not being used.

WHAT DOES THE ENERAC 942-XP DO?

The Combustion Efficiency Computer will measure and automatically display the efficiency of combustion of any furnace or boiler that uses any of the fuels for which it is programmed. In addition, it will measure the oxygen, carbon monoxide, combustible contents of the flue stack gases and the net stack temperature (i.e. temperature rise above ambient). All measurements are displayed on two 1/2" high 3-1/2 digit liquid crystal displays as follows:

The bottom display reads carbon monoxide concentration continuously and solely.

You can select the reading of the top display by pushing down the appropriate button of the Display Selection Switch.

When you turn on the printer, you will get a printout of all the combustion parameters indicated by the displays and, in addition, the time and date of the measurement and also the boiler identification selected number will appear.

You can also use the Combustion Efficiency Computer to carry out a smoke spot test.

There is also an additional "warning" flashing light that will turn on, if the carbon monoxide in the stack exceeds 50 ppm (0.005%). (On some instruments the light can be ~~is~~ set for 200 ppm also.)

Two recorder outputs are available for connection to any high impedance DC recorder with a 10 V. input. (See specs)

A. FACE PLATE LAYOUT

The various color shades on the face plate are intended for clarity when reading any of the many stack parameters that this instrument is capable of. Thus, for examples, the red color zone is reserved solely for carbon monoxide readings and adjustments.

CONTROLS AND DISPLAYS

1. OFF BUTTON: To turn the instrument off, push this button down. It should also be pushed down when the batteries are being charged.
2. SMOKE TEST ON BUTTON: To carry out a smoke spot test, insert a piece of smoke filter paper into the probe handle and push this switch down. The yellow "SMOKE" light (3)

will turn on and the pump will start running to complete one cycle of the smoke test. To repeat a smoke test, push the "OPER" button (4) down and then push the smoke test button again.

3. SMOKE TEST INDICATOR: This yellow light turns on when the smoke test button is depressed and remains on during a smoke test cycle.

4. OPERATE BUTTON: Push this button down to carry out all measurements (except the smoke test). When the AC cord is connected to the instrument, the batteries are disconnected from the circuits, if the OPERATE button is pushed down.

5. BATTERY OK INDICATOR: When either the OPERATE or SMOKE button is pushed down, this red LED indicating light will turn on. When the instrument is operated on batteries, the light intensity is an indication of the condition of the batteries. If the light turns on very weakly or does not turn on at all, the batteries require a charge.

6. AC-CHARGE OUTLET & FUSE: The AC cord is connected to this outlet plug that is located in the rear of the instrument in order, to either charge the batteries, or operate the instrument on AC. A one (1) AMP fuse is located next to the outlet.

7a. OUTPUT JACK: This jack is used to connect the instrument to an external high impedance (300K ohms) analog meter or recorder. Depress any of the display select push buttons ((9) through (13)) to obtain the desired signal on the OUTPUT jack. Output level is 0-10V maximum with the tip positive.

7b. CO OUTPUT: This jack gives a continuous voltage output that is proportional to the carbon monoxide concentration solely, as indicated by the bottom display.

8a-8e. FUEL SELECTOR SWITCH: Push the appropriate button down to select the fuel used by your furnace or boiler. Standard fuel selections are; coal, #2 Oil, #6 Oil, Natural Gas and Propane. Other fuels (i.e. coke oven gas, etc.) can also

be programmed upon request. This switch affects the reading of EFFICIENCY and carbon dioxide (CO_2) only. The readings of temperature, combustibles, carbon monoxide and oxygen are not affected by this switch.

9. TEMPERATURE DISPLAY BUTTON & TOGGLE SWITCH: To obtain an upper display reading of the temperature rise above ambient of the gases in the stack, push this button down while the instrument is operating. The temperature rise will be shown in degrees Fahrenheit, if the toggle switch points down and in degrees Celcius, if the toggle switch points up. Maximum temperature indication is 1999°F.
10. COMBUSTIBLES DISPLAY BUTTON: With the instrument operating, push this button down to obtain a reading on the upper display of the combustibles concentration in the stack gas in % by volume. Combustibles consist primarily of low density hydrocarbons (i.e. methane). Some hydrogen and carbon monoxide may also be present. Maximum reading is 2.5% in 0.01% steps.
11. OXYGEN DISPLAY BUTTON: With the instrument operating (and carbon dioxide toggle switch pointing down), push this button to obtain a reading on the upper display of the oxygen concentration by volume. (Oxygen concentration in air is 20.9%). Maximum reading is 25% in 0.1% steps.
12. CARBON DIOXIDE TOGGLE SWITCH: When the OXYGEN button is depressed and this toggle switch is pushed to the upper position, the instrument calculates and displays the carbon dioxide concentration of the stack gases on the basis of the oxygen concentration and the type of fuel used. There is no separate carbon dioxide sensor in the instrument. Range is 0-20% in 0.1% steps.
13. EFFICIENCY DISPLAY BUTTON: With the instrument operating and the probe inserted in the stack, push this button down to obtain an instantaneous reading of the efficiency of combustion of the furnace or boiler. The combustion efficiency is computed for furnaces and boilers only and not for any other devices such as internal combustion

engines, etc. Maximum reading is 99% in 0.1% steps. Disregard any efficiency reading, if the oxygen concentration exceeds 18% or the temperature rise is less than 20°F.

14. CARBON MONOXIDE WARNING INDICATOR: This is a red flashing LED indicator that will turn on, if the carbon monoxide concentration exceeds 50 ppm (0.005%). It will turn off when the CO concentration drops below 42 ppm. When turning the instrument on, this light may momentarily start flashing. This is due to instrument warm up (approximately 30 seconds warm-up is required for the carbon monoxide sensor).
15. (LOWER) DIGITAL DISPLAY: This is a standard 1/2" high 3-1/2 digit liquid crystal display that gives an indication of the carbon monoxide concentration at all times. Range is zero to 1999 ppm CO. A reading of 1 indicates overrange.
16. (UPPER) DIGITAL DISPLAY: This is also a 3-1/2 digit liquid crystal display for reading any of the remaining stack temperatures depending on the setting of the display selector switches (9) through (13).
17. THERMOCOUPLE INPUT: Connect here the 1/4" phone plug that is located at the end of the probe. This is also the thermocouple cold junction and should be at ambient temperature.
18. GAS INPUT: Connect the hose end of the probe here to draw a sample of the stack gas into the instrument.
19. FILTER WINDOW: The disposable filter is located directly below this window. The filter must be replaced as soon as there is noticeable discoloration.

ADJUSTMENTS

Numbers 20 through 27 show all the possible adjustments that can be made on the instrument. Those adjustments that are labeled should be carried out before taking a measurement, while those that are not labeled should be touched only during laboratory calibration of the instrument. Push down the

appropriate button when making an adjustment that will be read by the upper display.

20. TEMPERATURE ZERO ADJUSTMENT: This adjustment is used to obtain a temperature rise reading of zero on the upper display, when the temperature display button is pushed down and the probe is connected to the instrument and drawing ambient air. Make sure the probe tip is at room temperature before making this adjustment.
21. OXYGEN ZERO ADJUSTMENT: (Not labeled) Remove the black canoe plug to reach this adjustment with the small screwdriver during gas calibration of the instrument. DO NOT TOUCH THIS ADJUSTMENT WHEN USING THE INSTRUMENT IN THE FIELD.
22. OXYGEN GAIN (SPAN) ADJUSTMENT: This adjustment is used to obtain an oxygen reading of 20.9% when the oxygen button is pushed and the instrument is drawing atmospheric air.
23. COMBUSTIBLES ZERO ADJUSTMENT: Allow the instrument to warm up at least five minutes before making this adjustment. Push the carbon monoxide button down and let the instrument draw ambient air. Set the potentiometer approximately in the middle of its zero travel.
24. COMBUSTIBLE SPAN ADJUSTMENT: (Not labeled) Pull out the black canoe plug and insert a small screwdriver to adjust the combustibles span when carrying out a gas calibration of the instrument in the lab with 0.1% methane gas. DO NOT TOUCH THIS ADJUSTMENT WHEN USING THE INSTRUMENT IN THE FIELD
25. CARBON MONOXIDE ZERO ADJUSTMENT: Use this adjusment to obtain a zero reading on the lower display when the instrument is drawing clean surrounding air.
26. CARBON MONOXIDE SPAN ADJUSTMENT: This adjustment should be used in the laboratory only when calibrating the instrument with calibrated CO span gas.
27. PREHEAT ADJUSTMENT: (Not labeled) If your boiler uses an economizer, which preheats the combustion air, you must use this adjustment to zero out the temperature with the

probe inserted tin the combustion air stream, prior to inserting it to the stack.

There are four additional potentiometric adjustments inside the instrument that should rarely, if ever, be touched. One is located on the display PC board (1 V reference adjustment), the other three are located on the main PC board. (One is the CO_2 zero adjustment,the second the efficiency adjustment, and the third the smoke timer.)

28. PUMP TUNING KNOB: The pump can be tuned mechanically for maximum flow by turning the knob until a clicking sound is heard and then backing off a quarter turn.
29. OXYGEN SENSOR
30. CARBON MONOXIDE SENSOR
31. COMBUSTIBLES SENSOR

PRINTER SECTION

32. PRINTER ON-OFF TOGGLE SWITCH: To activate the printer you must first turn this switch ON. Keep this switch OFF when you are not yet ready to use the printer during a boiler tune up in order to save the batteries.
32. PUSH TO PRINT SWITCH: Push down this switch whenever you wish to get a printout. It takes approximately one minute to get a complete printout.
34. BOILER ID # SWITCH: This is a convenient digital thumbwheel switch that allows you to identify the boiler from which the printout has been obtained. You can identify up to 99 different boilers. (You may wish to use #00 as an instrument calibration printout before taking a measurement.)
35. PRINTER: This is a 3" wide 40 character/line SEIKO thermal printer. When activated it prints in sequence; Boiler ID #, Date, Time, Fuel, Temperature Rise, Combustibles, Oxygen, Carbon Dioxide, Carbon Monoxide and Efficiency. It also prints; Test Performed By, Next Test Date, and Comments.
36. PRINTER PAPER: This is a role of special thermal paper that is coiled under the access plate of the printer.

37. CLOCK SET THUMBWHEEL SWITCH: This switch is located under the printer access plate and is used to select the various functions when setting the clock.

38. CLOCK SET PUSH BUTTON SWITCH: This switch is also located under the printer access plate and is used to set the clock.

39. PAPER ADVANCE THUMBWHEEL

B. HOW THE ENERAC MEASURES THE COMBUSTION PARAMETERS

The Combustion Efficiency Computer, directly measures the three most important factors affecting the efficiency of combustion. These factors are temperature, oxygen and the incompletely burned products of combustion such as carbon monoxide and combustibles. The oxygen, temperature and combustibles information is fed into an electronic computing network, which instantaneously computes and displays the efficiency of combustion for the type of fuel used.

There are four sensors that detect the combustion parameters.

1. The oxygen sensor is a sealed disposable electrochemical galvanic cell that has excellent stability and speed of response. It gives an electric current that is proportional to the concentration of oxygen in the stack gases. Its life is warranted for six months.

2. The combustibles sensor is of the sintered semiconductor type chosen to have a sensitivity, which is about five times higher for methane gas than for carbon monoxide (which is also a combustible gas). It operates on the principle of adsorption of combustible gas molecules on the semiconductor surface and consequent decrease of the semiconductor resistance. The three main combustible gases found in the stack are Methane, Hydrogen and Carbon Monoxide. Other combustible gases are also formed. The basic advantage of this type of sensor over the catalytic combustion type is its high sensitivity to relatively low concentrations of combustibles. This sensor has a long life, normally in excess of two years.

3. The carbon monoxide sensor is a disposable highly sensitive electrochemical cell that gives an output electric current that is proportioned to the carbon monoxide concentration over its entire range. It's expected life is 1-2 years.

There are two types of CO sensors available. The standard sensor exhibits some interference from sulphur dioxide. The "S" sensor (optional) exhibits no interference from SO_2 and should be used if you are burning high sulphur oil or coal.

4. The temperature sensor is a type "K" (Chromel-Alumel) thermocouple. It generates a voltage that is propotional to the difference between the stack and ambient temperatures. (Ambient temperature is taken as the temperature of the face plate of the instrument).

C. PREPARING THE ENERAC FOR A MEASUREMENT

If you wish to simply check the operation of the boiler and obtain a record, you can do so in less than 5 minutes using the ENERAC. If you wish, however, to carry out a complete tune up of a boiler that has different firing rates, you may have to use the instrument for half an hour or more.

NOTE:

If you are planning to operate the instrument for more than five minutes at a time, it is strongly recommended that you use a water trap. Otherwise, condensing excess moisture from the stack gases will eventually be drawn into the oxygen housing causing the oxygen sensor to malfunction temporarily. It is a good idea to always use a water trap, available from the factory, when operating the instrument.

To prepare the instrument for a stack measurement, follow the simple procedure outlined below:

1. Unfold the stack probe. Make sure that there are no kinks in the hose that might obstruct the flow of gas. Connect the end of the stack probe to the appropriated gas and thermocouple connectors on the faceplate of the instrument as follows. Connect the end of the hose to the gas input

on the faceplate of the instrument by simply pushing down the female gas fitting that is located at the end of the hose into the male bulkhead fitting that is located on the faceplate, while simultaneously pulling back the round collar of the female fitting. When the fittings are properly connected, they will be locked together and you cannot simply pull them apart. After connecting the gas fittings, take the 1/4" phone plug that is located at the end of the probe and push it down into the TEMP SENSOR jack on the faceplate. Make sure the plug is pushed into the jack as far as it will go to ensure proper contact.

2. Push down the appropriate button of the fuel selector switch that corresponds to the fuel being used and also push down the "TEMP" button.
3. If you plan to run the instrument on AC, plug the AC cord to the rear of the instrument. Use a 120 VAC 60 HZ outlet only. If you wish to use the instrument on batteries, disconnect the cord. Push the "OPER" button down. The battery "OK" light will go on and you will immediately hear the instrument pump running and drawing ambient air. Wait a minimum of two-three minutes to allow the instrument to warm up.
4. Zero the instrument as follows:

   Do not insert the probe to the flue stack yet, but let it draw atmospheric air. After a two minute warmup (up to 15 minutes may be required if the instrument is very cold) press the button marked "OXY". The upper display should read 20.9% (which is the oxygen content of air). If the display is more than 0.2% off the desired reading, use the small screwdriver provided and very slowly rotate the multiple turn potentiometer adjustment marked "O_2 Adj" until you obtain the correct reading (turn the potentiometer clockwise to increase the reading). The oxygen sensor is now calibrated.

In a similar manner the temperature sensor may be calibrated by depressing the button marked "TEMP". The upper display should read 000 (which is the temperature difference between the probe tip and ambient). The temperature adjustment is located below the hole marked "TEMP ADJ". Also, the instrument has a zero adjustment for combustibles. Depress the "COMB" button. The upper display should read 0.00. The zero adjustment is located below the hole marked "COMB". Finally, using the carbon monoxide zero adjustment, set the lower display for a reading of zero. (WHEN ZEROING THE CARBON MONOXIDE DISPLAY, THE SURROUNDING AREA MUST BE COMPLETELY FREE OF ANY SMOKE OR RESIDUAL FUMES.)

D. TAKING STACK MEASUREMENTS WITH THE ENERAC

Insert the instrument probe into the flue stack through a suitable 3/8" hole. The tip of the probe should reach as close to the center of the stack as possible. The main body of the metal probe must not touch the wall of the stack. The point where the probe is inserted should not be more than 12" from the outlet of the boiler and at least two flue pipe diameters before any barometric draft control, such as flue dampers.

Allow the boiler to reach steady state conditions.

1. Reading Temperature, Oxygen, Combustibles & Carbon Monoxide

It is a good idea to start your measurements by reading the net stack temperature of the boiler first. Your instrument reads net temperature (i.e. stack temperature minus ambient temperature) in degrees Fahrenheit or Celcius, up to a maximum reading of 1999°F. By monitoring the stack temperature first, you make sure that the boiler has reached steady state conditions. After measuring stack temperature, depress the "COMB" button and read the % of combustibles in the flue gas, if any. Maximum combustibles reading by the instrument is approximately 2.5%. Next, push the oxygen button down and take a

reading in % of the oxygen concentration in the stack gases. The % of oxygen in the gas is an indication of the amount of excess air which contributes to losses in efficiency. The instrument is capable of reading an oxygen concentration of up to 25%.If you are more familiar with carbon dioxide levels in the stack gases push the CO_2 toggle switch to its upper position. You will get an indication of the CO_2 level based on the oxygen concentration.

While switching the upper display during your measurements, you can simultaneously monitor the lower display for any carbon monoxide in the stack. If the CO level exceeds 50 ppm the flashing warning light will turn on.

2. Reading Boiler Efficiency

The instrument is capable of automatically computing the efficiency of combustion of any boiler which uses any of the fuels for which is has been programmed.

To read the efficiency, simply push down the button marked "EFF" and the upper display will indicate in % the efficiency of combustion.

2a. How the Efficiency is Computed

The instrument computes the efficiency of combustion by the stack heat loss method. According to this method, the fractional amount of useable heat carried away in the stack is substracted from 100% to give the combustion efficiency. There are three heat loss mechanisms: heat carried away by the hot dry gases in the stack, heat lost in heating the water to steam, which is formed by the burning of hydrogen, and heat loss due to incompletely burned by-products of combustion that are called collectively combustibles. The instrument takes into account all three factors in computing the efficiency.

The carbon monoxide sensor has an expected life of one to two years. Consequently, it will rarely require replacement. To replace an old or defective sensor, remove the cover plate. Using a medium size screwdriver remove the three screws that secure the carbon monoxide sensor on top of the housing's cover plate. Lift the sensor carefully and remove the three wires that are attached to it.

Take a new sensor. Carefully cut (or remove) the wire that shorts the black and the green (or blue) terminal. Connect the three wires to their respective pins on the new sensor observing the correct color code. Make sure the O-ring located in the grove on the top of the white housing plate is in place. Carefully secure with the three screws the sensor on top of the plate making sure there is no air leak. Wait fifteen minutes before calibrating the instrument.

IMPORTANT NOTICE:

If at any time the CO sensor has been disconnected from the instrument for more than 10 minutes, or if the sensor has been exposed to excessive concentrations of CO (i.e. the display overranged indicating a one only), you must wait a day before attempting to recalibrate the CO sensor. A CO sensor that has been exposed to excessive CO gas will exhibit the following behavior: It will not drop back to zero for quite some time. It will then give negative readings for a while, before finally going back to zero.

4. The Bronze Filter

The bronze filter inside the optional condensation trap must be replaced when it gets dirty. To replace the bronze filter, unscrew the plastic bowl of the condensation trap. Unscrew the bronzefilter and replace it with a standard 100 micron bronze filter. Make sure the plastic bowl is screwed back tightly to avoid any air leaks.

(Export models are designed so that the loss caused by water formation may be ignored, if desired, by simply removing one component that is located on the main printed circuit board of the instrument). If the net stack temperature drops below 130°F the instrument assumes that condensation occurs and adjusts the efficiency accordingly.

3. Using the Printer

At this time, and before making any adjustments to the boiler, you may wish to obtain a printout that will record the operating conditions of the boiler as found.

To obtain a printout, first assign the boiler under test an identification number between 1 and 99 and set the Boiler ID # switch to the assigned number. (This is a very useful feature, if more than one boiler is tested). Push the printer ON-OFF toggle switch to the ON position. Push the PUSH TO PRINT button down. The printer will then print the following:

ENERAC
Combustion Test Record
Date: XX/XX
Time: XX:XX
Fuel: XXXX
Temperature Rise: XXXX°F
Combustibles: X.XX%
Oxygen: XX.X%
Carbon Dioxide: XX.X%
Carbon Monoxide: XXXX PPM
Efficiency: XX.X%
Test Performed By:
Next Test Date:
Comments:

To save the batteries, leave the printer ON-OFF switch in the OFF position when the printer is not used.

4. Improving Boiler Efficiency

The ENERAC Model 942-XP is the most advanced portable instrument for manually tuning up your boiler. Boiler tune ups using the ENERAC has the following three advantages:

a. Improves boiler safety against hazardous explosions, or exposure of personnel to toxic gases.

b. Contributes to longer boiler life.

c. Improves boiler efficiency and cuts fuel costs.

To carry out a boiler tune up you must follow the boiler manufacturer's recommendations. What follows is a brief general guideline and is not intended to use with any specific boiler.

Y u improve boiler efficiency by keeping the temperature of the stack gases as low as possible (i.e. maintaining a clean heat exchanger) and by introducing the minimum amount of air that is required to burn the fuel completely and without significant generation of combustibles.

The ENERAC Model 942-XP allows you to simultaneously monitor the amount of excess air (as measured by the oxygen concentration) and the amount of combustibles and carbon monoxide. Carbon Monoxide is highly toxic and should not exceed 200-300 PPM in the stack.

To maximize efficiency you reduce the air/fuel ratio until either Carbon Monoxide or Combustibles become appreciable (i.e. Combustibles should remain less than 0.07%).

Remember, if the boiler has different firing rates, different settngs of air/fuel ratios are required, corresponding to the firing rates.

After the boiler has been adjusted, it is a good idea to obtain a print out of the boiler's parameters again, in order to maintain a record of the improvement and also as a basis of comparison with the boiler's next test.

5. The Smoke Test

Smoke (unlike combustibles, which are gases) consists of very fine solid particles of unburned carbon mixed together with tar particles. Some smoke is also present in the stack, especially if #6 oil or coal is burned.

The Combustion Efficiency Computer can be used to carry out smoke tests using the conventional ASTM method of comparing the discoloration of a piece of smoke filter paper with a set of standard shades of gray.

To carry out a smoke test, you must insert a sample filter paper into the cutout that is located in the stack probe handle. To insert the paper, pull back with one hand on the spring loaded shaft which is located on the rear of the probe handle. With the other hand, insert the paper and then release the shaft. The paper should be pressed firmly between the teflon and neoprene washers. Insert the stack probe into the stack and push down the button marked "SMOKE". Immediately, the yellow "SMOKE" light on the faceplate will light up and the pump will turn on. During the Smoke Test, disregard all display readings except temperature. After approximately 2 minutes (the exact time depends on the capacity of the pump), the yellow light will go off and the pump will stop. Take the probe out of the stack, pull back the spring loaded shaft

and remove the filter paper. Compare it with the set of standard shades provided by the smoke chart.

To avoid any condensation from reaching the filter paper, it is a good idea when carrying out a smoke test to tilt the edge of the probe slightly downwards into the stack.

E. SHUTTING DOWN THE INSTRUMENT

When the measurements are finished, carefully withdraw the probe from the stack and vigorously shake it with the probe tip pointing down. Be careful not to touch the probe. Disconnect the hose from the instrument and keep it vertical. Shake it well to allow condensing moisture to run out of it. Disconnect and empty the water trap, if used. Allow the instrument to run without the probe connected for about 2 minutes to remove excess humidity from the sensor housings. Turn the instrument off by pushing the OFF button down.

F. INSTRUMENT CALIBRATION

The instrument's performance should be checked occasionally (every 4-6 months) to make sure that your stack readings are within the specified accuracy range.

If you wish to have the instrument completely calibrated, you may return it to the factory. The instrument will be recalibrated using standard gases.

If you wish to carry out a complete calibration yourself, you must purchase a gas calibration kit from the factory. This kit includes a model stack, a flowmeter and a 32 liter bottle of custom certified calibration gas: 0.1% methane, 100 ppm carbon monoxide, balance nitrogen.

There are five calibration steps required by the instrument:

a) Oxygen Sensor Calibration and Air Leak Test

Plug the AC cord to a suitable 120 VAC outlet. Turn the instrument on by pushing down the "OPER" button and allow the instrument to reach complete warmup (10 minutes minimum with the stack probe connected to the instrument and drawing air).

Push down the "OXY" button and adjust the upper display for a reading of 20.9. Push the CO_2 toggle switch to its upper position. The upper display should give a reading of zero. (If it doesn't, there is an adjustment located inside the instrument on the main board. You can reach it by removing the small cover plate that is located on the left side of the instrument faceplate). After you have zeroed the CO_2 display, push the CO_2 toggle switch back down to its bottom position.

Connect the instrument probe to the gas calibration kit as shown in the kit instructions. Turn the calibration gas on and allow a flow of 2000 cc/min. The oxygen reading should go to zero within two minutes. You may make a zero adjustment, if necessary, using the OXY ZERO ADJ potentiometer (#21). Next, reduce the flow to 800 cc/min and observe the upper display. Any increase in the reading by more than 0.2% indicates an air leak in the instrument, which must be located. (Check the disposable filter and the cover plate of the oxygen sensor housing.)

b) Combustibles Calibration

Make sure the instrument has warmed up for at least 10 minutes drawing ambient air. Depress the "COMB" button. Pull out the black plug and rotate the COMBUSTIBLES ZERO ADJUSTMENT (#23) to zero the readout on the upper display. Connect the instrument to the gas calibration kit. Open the valve on on the top of

the model stack. Set the gas flow to 2000 cc/min. Wait one minute and then adjust the COMB. SPAN (#24) for a reading of 0.10%.

c) Carbon Monoxide Calibration

Allow the instrument to draw clean air (no tobacco smoke or automobile exhausts in the vicinity) for a few minutes. Adjust lower display for a reading of zero. Feed the calibration gas into the instrument at a rate of 1500 cc/min, approximately. Wait till the reading of the lower display has stabilized. Set the CARBON MONOXIDE SPAN ADJUSTMENT (#26) for the correct reading as shown on the calibration gas bottle.

d) Temperature Sensor Calibration

No calibration, except for the zero adjustment outlined in Section A is provided, but you may check the instrument's temperature accuracy by dipping the stack probe into boiling water. (DON'T CONNECT THE PROBE GAS FITTING TO THE INSTRUMENT OR YOU WILL FLOOD THE INSTRUMENT!)

Use a thermometer to check ambient temperature. The instrument reading should be 212^{o}F minus ambient temperature (within 7^{o}F).

e) Pump Flow Rate Adjustment

The instrument pump is powered by a regulated voltage. Its output should remain constant irrespective of the condition of the batteries. The flow rate of the pump can be adjusted by means of a tuning knob located on the pump itself. To tune the pump for maximum flow, remove the small access plate that is located on the left side of the face plate of the instrument. Insert your hand into the instrument and rotate clockwise the brass knurled knob, that is located on the suction

side of the pump, until you hear a clicking sound (the vibrating plate is hitting the coil). Back off 1/4 turn till the clicking sound stops. The pump is now tuned to maximum flow, which is typically 1500 cc/min, but should be no less than 900 cc/min in the OPERATE position. (To check the flow you need a low pressure drop flowmeter, such as the Gilmont #12).

The pump flow rate has no effect on any of the parameters you wish to measure with the exception of the smoke test. During the smoke test, the pump must pull a total flow of 1070 cc. in order to obtain the correct discoloration on the smoke paper. To check the accuracy of the smoke test, you will need a flowmeter with a scale of 0 to 2000 cc/min. Insert one smoke test paper into the stack probe handle. Connect the flowmeter to the end of the stack probe. Push down the smoke button. To get the correct total flow required by the smoke test you will have to adjust the duration of the smoke timing circuit. This duration is adjusted by a potentiometer that is located, approximately, near the left edge of the main printed circuit board of the instrument. Adjust the potentiometer so that the product of the flow rate (in cc/min) and timing cycle (in minutes) is equal to 1070.

G. MAINTENANCE

The instrument has been designed for field use and can withstand considerable handling. Care should be taken, however, to avoid dropping it or otherwise abusing it, since calibration is easily upset by abuse.

There are five components inside the unit that require occasional periodic replacement. These are the disposable fiberglas filter located inside the instrument, the oxygen

sensor, the carbon monoxide sensor, the printer paper, and the bronze 100 micron filter of the optional, but highly recommended, water trap.

1. The Disposable Fiberglas Filter

The disposable fiberglas filter is located directly underneath the face plate where the word "FILTER" is printed and it is visible through the small plastic window. When the filter becomes noticeably discolored, it must be replaced, otherwise the flow to the instrument will be blocked. To replace the filter, remove the small cover plate by simply twisting the quarter turn fasteners on each side. Reach under the opening and pull the filter out. Disconnect the clear tubing from it and replace the filter with a new one. Make sure that the filter is placed correctly with the flow direction as marked. Make sure that the clear tubing is connected to the new filter as far as it can go to avoid any leaks.

2. The Oxygen Sensor The oxygen sensor is a galvanic type fuel cell in the shape of a "C" size battery. It is located inside the white plastic rectangular housing which measures 2" x 2.5" x 3.5" and is accessible by removing the left coverplate. The sensor requires no maintenance during its life time which is guaranteed for six months. (A 20% extra life margin is built into it.) However, the sensor must not be allowed, under any circumstances, to get wet. A wet oxygen sensor will give either erratic or very low readings. It is not difficult to get the oxygen sensor wet if; a) you do not use a water trap, b) you allow the instrument to get very cold in winter. (This causes condensation on the surface of the cold sensor.) A wet sensor may be dried out by operating the instrument without the probe and letting it draw ambient warm air for three or four hours.

The oxygen sensor responds only to the oxygen present in the flue gas and is insensitive to the presence of other gases in the stack. It is only slightly sensitive to temperature fluctuations

requiring no temperature compensation. It will freeze at -10° to -15°C., but it is not damaged because of freezing. Its output is stable within 2-3% during its entire lifetime, thus seldom requiring any adjustments. The sensor must be replaced when the instrument can no longer be adjusted to 20.9% oxygen with the "OXYGEN GAIN ADJ" set at maximum.

2a. Replacing the Oxygen Sensor

To replace the oxygen sensor, pull out the small cover plate by turning the two half-turn fasteners counter-clockwise. The sensor is located inside the rectangular plastic block directly below the opening in the face plate. Use a screwdriver to remove the four screws that hold the top cover of the plastic housing. Lift the cover up and out of the instrument carefully pulling the oxygen sensor with it. Unscrew the oxygen sensor and throw it away. Take a new sensor and connect the red and black wires of the sensor to the housing cover observing the correct color code. With the sensor hanging from the housing cover, slowly drop the sensor into the cavity. Screw the top cover down tightly to avoid leaks. The new sensor is now in place.

If at any time you disconnect the oxygen sensor from the PC board, or if you replace it with a new sensor you must wait aproximately 15 minutes before making any gain adjustments. As soon as you connect an oxygen sensor to the PC board the upper display will give a maximum reading of 25%. Within 10 minutes the reading will drop and then you can adjust it to 20.9%.

Replacement oxygen sensors can be obtained from your local distributor or directly from the factory. You should not, however, stock oxygen sensors, since they have a limited shelf life.

3. The Carbon Monoxide Sensor

5. The Printer Paper

To replace the printer paper roll, remove the two screws that fasten the printer access plate to the face plate. Gently lift the access plate and remove the old roll from the shaft. Insert the beginning of a new roll into the bottom of the printer, while simultaneously rotating the printer thumbwheel. Push the shaft through the paper roll and the straps that hang from the access plate.

5a. Setting the Printer Clock

Before attempting to set the clock, turn the instrument on. Turn printer toggle switch to the ON position and allow the printer to stop.

To set the clock remove the printer access plate exposing a 15 position thumbwheel switch, called the register switch and a small pushbutton switch, called the clock set switch. You will also have to use part of the boiler ID # digital switch corresponding to the Most Significant Digit, called the MSD, ID switch. The register switch selects the clock registers as follows:

Register Switch Position	Clock Register
2	Units of minutes
3	Tens of minutes
4	Units of hours
5	Tens of hours *(See Note)
7	Units of days
8	Tens of days
9	Units of months
10	Tens of months
11	Units of years
12	Tens of years

NOTE: The tens of hours can be set only from 12:00 A.M. to 8:00 P.M. (20:00 hours) as follows:
From 12:00 A.M. to 9:59 A.M. set MSD switch to 8
From 10:00 A.M. to 19:59 (7:59 P.M.) set MSD switch to 9

To set any one of the eight clock registers use the following procedure:

a) Set the register switch to the number corresponding to the desired register.

b) Set the MSD, ID switch to the number corresponding to the desired value for that register.

c) Push down the clock set switch.

Repeat the procedure as necessary.

For example, to set the clock to indicate 15:27 hours:

a) Set register switch to 5

b) Set MSD, ID switch to 9 (tens of hours between 10:00 and 20:00)

c) Set register switch to 4

d) Set MSD, ID switch to 5

e) Set register switch to 3

f) Set MSD, ID switch to 2

g) Set register switch to 2

h) Set MSD, ID switch to 7

PRINTER:

SEIKO, MTP-401, 3", 40 characters/line, 7x5 dot matrix thermal printer. Character size 2.4 x 1.1 mm. Printing speed 0.7 lines/sec Crystal controlled internal digital clock gives a printout of time and date.

ENVIRONMENTAL Temperature: 0°C to 50°C
Humidity: 10% to 95% R.H.
Maximum Stack Temperature: 2100°F
Maximum Stack Draft: 2" Water

PERFORMANCE

Warm Up Time: 2 minutes minimum for combustibles indication. 30 seconds for oxygen and carbon monoxide indications.

RESPONSE TIME: (90% of reading)
Temperature: 1 minute
Oxygen: 20 seconds
Combustibles: 20 seconds
Carbon Monoxide: 45 seconds

RANGES:
Oxygen: 0 to 25%
Temperature (Net): 0-1999°F
Combustibles: 0-2.5% (25,000 PPM)
Efficiency: 0 to 99%
Carbon Monoxide: 0-1999 PPM

RESOLUTION:
Oxygen: 0.1%
Temperature (Net) = 1°F
Combustibles: 0.01% (100 PPM)
Efficiency: 0.1%
Carbon Monoxide: 1 PPM

COMBUSTION EFFICIENCY COMPUTER
EES MODEL 942
SPECIFICATIONS

PHYSICAL

Size: 9" x 13" x 10"
Weight: 12 lbs.
Material: Aluminum Drawn Case

ELECTRICAL

Power Requirements: Battery operated - (Six rechargeable Ni-Cad Batteries) 4 hours continuous operation, overnight charging.

or

120 VAC/60 HZ / 1 Amp (using AC cord)

READ OUT

Upper Display: Digital, 1/2" high 3-1/2 digit liquid crystal display.

Lower Display: Same as upper display.

Recorder Output: Switchable by means of the display selector switches.

EFF: 0-3.0 V DC (0-99% Eff.) into load in excess of 200 K ohms.

TEMP: 0-6.0 V DC (0-1999^{o}F) into load in excess of 200 K ohms.

OXY: 0-0.74 V DC (0-25% O_2) into load in excess of 200 K ohms.

COMB: 0-0.79 V DC (0-2.5% COMB) into load in excess of 200 K ohms.

CO Recorder Output: CO: 0-10 V (0-2000 ppm) into load in excess of 1 K ohms.

ACCURACY:

Oxygen: ± 0.3% (with linearization compensation)
Combustibles: ± 10% for 1000 PPM methane in nitrogen, 60°F
Temperature: ± 7°F
Efficiency: ± 1% (75%-90%), ± 3% (0%-95%)
Carbon Monoxide: ± 5% of reading

CARBON MONOXIDE WARNING: 50 PPM CO (0.005%) or 200 PPM

TYPE OF FUEL: Coal, #2 Oil, #6 Oil, Propane Gas, Natural Gas (1000 BTU/cf). Push button selection.

SMOKE TEST: 1-1/2 min. approx., smoke paper method, 0-9 Bach. No.

GAS SAMPLING:

12" Inconel 600 and aluminum probe with thermocouple and 10' of black latex hose.

SENSORS:

Oxygen: Galvanic fuel cell. Disposable. Minimum life 6 months.
Temperature: Thermocouple type K
Carbon Monoxide: Electrochemical cell. Minimum life 6 months.
Combustibles: Semicondutor type, lifetime indefinite.

TROUBLE SHOOTING GUIDE

The following list may prove helpful in case of a problem. If lists some of the reasons, in order of decreasing probability.

Unit will not turn on and operate on batteries:

1. AC cord jack does not make proper contact, or fuse is burned out.
2. Batteries are completely discharged.Charging resistor
3. burned out.
4. "OPERATE" switch is defective.

Unit will operate on batteries, but does not operate on AC.

1. Fuse is burned out.
2. Relay is defective.

Operate light turns on but pump is not running.

1. Connector from shock plate to bottom of main PC board is loose or has fallen off.
2. Broken wire to pump.
3. Pump transistor is burned out.

Batteries will not hold charge.

1. Defective cell in batteries.
2. Charging resistor burned out.
3. Batteries are shorted.

Display remains blank or fades out after a minute.

1. Batteries are discharged.

TROUBLE SHOOTING GUIDE

The following list may prove helpful in case of a problem. If first note of the reasons, do order of increasing probability.

Unit will not turn on and operate on batteries:

1. DC cord jack does not make proper contact, or fuse is
2. burned out.
3. Batteries are completely discharged.Charging resistor
4. burned out.
5. "ISOLATE" switch is defective.

Unit will operate on batteries, but does not operate on AC.

1. Fuse is burned out.
2. Relay is defective.

Operate lights turns on but pump is not running.

1. Connector from shock plate to bottom of main PC board is
2. loose or has fallen off.
3. Broken wire to pump.
4. Fuse transistor is burned out.

Batteries will not hold charge.

1. Defective cell in batteries.
2. Charging resistor burned out.
3. Batteries are shorted.

Display reading blank or fades out after a minute.

1. Batteries are discharged.

2. Instrument is too cold, allow it to warm-up.
3. 5 V regulator defective.

Segment missing from one of the display digits.

1. Loss of contact between the LCD and one of the holding pins. (Face plate must be removed to correct this.)

Display indicates only a 1. (Overrange indication)

1. Level exceeds display range.
2. Loose or open connector from sensor to PC board.
3. 5 V regulator defective.

Temperature cannot be adjusted to zero with ambient air.

1. Make sure probe and instrument case have been exposed to the same temperature.
2. Thermocouple phone plug tip is defective.
3. Thermocouple amplifier is burned out.

Temperature reading does not go up when probe is inserted in stack.

1. Make sure thermocouple plug is all the way into the socket.
2. Thermocouple wire or tip is broken. (Try another probe.)

Combustibles sensor cannot be adjusted to zero with ambient air.

1. Wait a few minutes for the sensor to warm up , then try again.
2. Make sure ambient air is clean; no smoking or paint fumes, etc. present.

Combustibles sensor does not go back to exactly zero when probe is removed from stack.

1. Wait 2 minutes.
2. Insufficient warm-up time, recalibrate to zero and measure again.

CO Display will not zero

1. Make sure environment is completely free of carbon monoxide smoke and other residual fumes.
2. CO sensor was exposed to excessive CO in the stack. Wait one day.
3. CO sensor must be defective.

CO reading in stack "seems to high".

1. Make sure furnace is operating properly.
2. Check calibration with 100^{0} PPM (0.1%) calibrated CO gas.

CO reading fluctuates in stack.

1. No problem - draft probably is too high; causes CO and erratic flame.
2. Furnace burning defective.
3. CO sensor damaged.

Oxygen reading cannot be adjusted to 20.9 with ambient air.

1. Disposable filter must be replaced. (Blocks flow of air).
2. Hose is kinked - straighten hose.
3. Moisture covers oxygen sensor tip. Run instrument for a few minutes; if problem is not corrected, then remove oxygen sensor, wipe tip with soft cloth. Recheck.
4. Sensor is used up (six month life). Replace oxygen sensor.

Combustible sensor does not go back to exactly zero when probe is removed from stack.

1. Wait 2 minutes.
2. Insufficient warm-up time, recalibrate to zero and measure again.

CO Display will not zero

1. Make sure environment is completely free of carbon monoxide smoke and other residual fumes.
2. CO sensor was exposed to excessive CO in the stack. Wait one day.
3. CO sensor must be defective.

CO reading in stack "peaks to high".

1. Make sure furnace is operating properly.
2. Check calibration with 100# gas (0.1%) calibrated CO gas.

CO reading fluctuates in stack.

1. No problem - draft probably is too high; causes CO and erratic flame.
2. Furnace burning defective.
3. CO sensor damaged.

Oxygen reading cannot be adjusted to 20.9 with ambient air.

1. Disposable filter must be replaced. (blocks flow of air).
2. Hose is kinked - pinched hose.
3. Moisture covers oxygen sensor tip. Run instrument for a few minutes; if problem is not corrected, then remove oxygen sensor, wipe tip with soft cloth. Recheck.
4. Sensor is used up (six month life). Replace oxygen sensor.

Smoke timer seems too long (longer than 2-1/2 minutes).

1. Capacitor leakage on initial chargeup. Take another reading.
2. Adjust trimmer potentiometer, so that $t_{sec} = \frac{1070}{A}$ where A = flow ml/min with smoke paper in place.

On smoke, (with paper inserted), pump becomes very noisy.

1. It is OK. Slightly detune pump, if noise is a nuisance.

Unit does not operate when smoke button is pushed.

1. Smoke trimmer has been turned all the way down.
2. Defective switch.